Astronomy 150:
Killer Skies
MWF 1300-1350
141 Wohlers Hall

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Office Hours:
  W: 11:00-11:59 a.m.
    or by appointment or email

This Class (Lecture 2):

  Poor Pluto

Next Class:
  Astro-Death is very unlikely

http://eeyore.astro.uiuc.edu/~lwl/classes/astro150/spring09/
   (simpler to google-me, then click on 150 link)

Music: *Millions of Miles from Home* – Dune

Outline

- What the hell happened to Pluto?
- The speed of light!
- Scale of the Solar System
  – Freaky Big!

What happened to Pluto?

http://orbitingfrog.com/blog/wp-content/uploads/2008/07/poor_pluto_mathias_pedersen.jpg

The War of "What is a planet?"

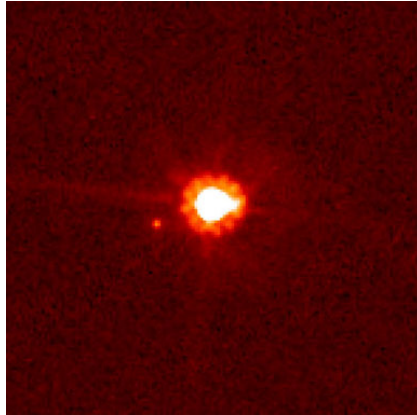THERE CAN BE NO PEACE UNTIL THEY ACCEPT THAT PLUTO **IS** A PLANET!
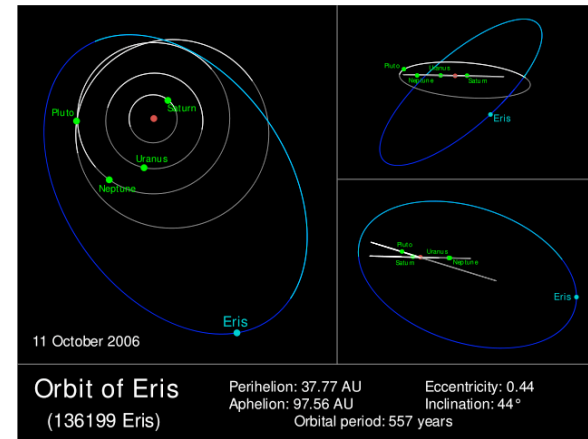
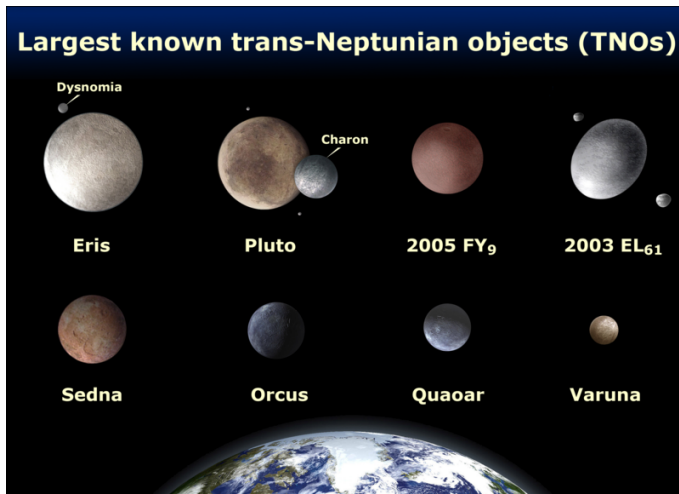© The Rocky Mountain News. Dist. by NEA, Inc.

What's Changed?

- The object Eris discovered in 2005
- ~20% larger than Pluto
- ~30% more massive than Pluto
- Has a moon (Dysnomia)
- Weird orbit
- Planet?

The Planet Eris?

11 October 2006

Orbit of Eris
(136199 Eris)

Perihelion: 37.77 AU
Aphelion: 97.56 AU
Eccentricity: 0.44
Inclination: 44°
Orbital period: 557 years

Planet or Plan-not?

Largest known trans-Neptunian objects (TNOs)

Dysnomia

Charon

Eris   Pluto   2005 FY$_9$ 2003 EL$_{61}$

Sedna   Orcus   Quaoar   Varuna

What is a Planet?

A planet is a celestial body that

(a) has sufficient mass for its self-gravity assumes a nearly round shape, and

(b) is in orbit around a star, and is neither a star nor a satellite of a planet

12 Planets?

My Very Eccentric Mother Curiously Just Showed Us Nine Pianists Conducting Encores
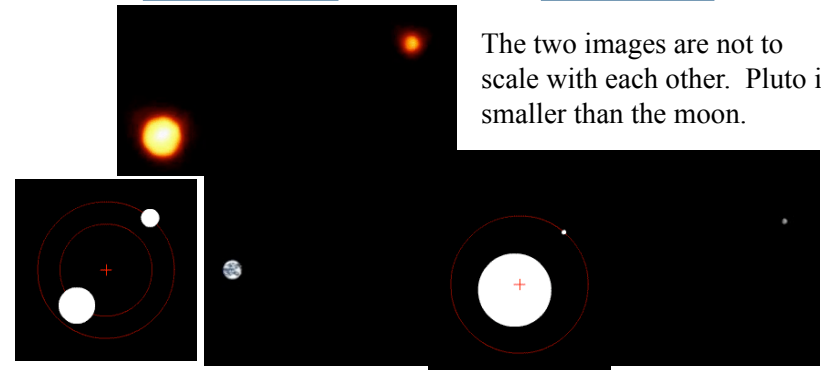
My Very Excellent Mother Just Served Us Nine Pizzas

Why Charon and not our Moon?

Pluto-Charon

Earth-Moon

The two images are not to scale with each other. Pluto is smaller than the moon.

When a moon orbits a planet, or a planet orbits a star, both bodies are actually orbiting around their *center of mass*
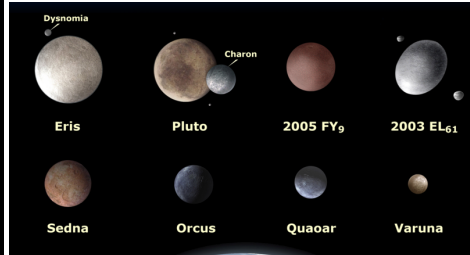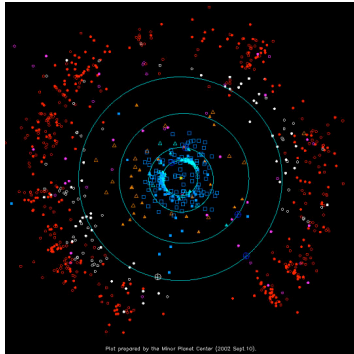
Two Dozen Planets???

The Alternate Proposal

A planet is a celestial body that

(a) has sufficient mass for its self-gravity assumes a nearly round shape, and

*(b) is in orbit around a star, and is neither a star nor a satellite of a planet, **and***

*(c) **has cleared the neighborhood around its orbit***

This definition would exclude Pluto (and others)
because it's one of many...

Dysnomia

Charon

Eris   Pluto   2005 FY$_9$ 2003 EL$_{61}$

Sedna   Orcus   Quaoar   Varuna

Plot prepared by the Minor Planet Center (2002 Sept 10).

Red & white dots show other Pluto-like objects
discovered around & beyond Neptune's orbit

The Results...

8
~~Nine~~ *Planets*

MERCURY VENUS EARTH MARS JUPITER SATURN URANUS NEPTUNE PLUTO
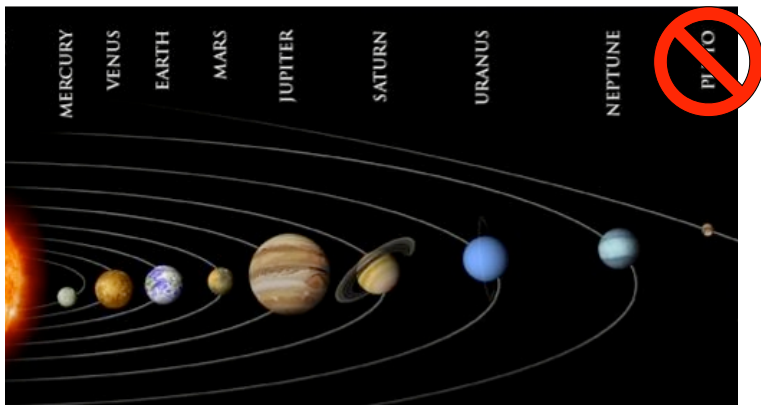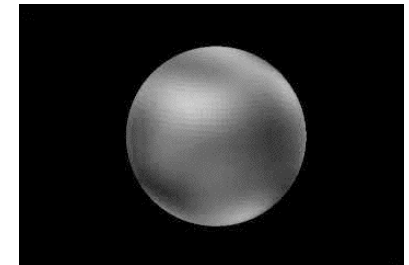
My Very Excellent Mother Just Served Us Noodles!

So what do we call Pluto now?

Planet-ish objects that meet the earlier definition, but fail to
make the grade because of the new criterion would be
called *dwarf planets*

Not Here in Illinois!

- Clyde Tombaugh, discovered Pluto, was from Illinois, so the Illinois State Senate made a resolution
  - RESOLVED, BY THE SENATE OF THE NINETY-SIXTH GENERAL ASSEMBLY OF THE STATE OF ILLINOIS, that as Pluto passes overhead through Illinois' night skies, that it be reestablished with full planetary status, and that March 13, 2009 be declared "Pluto Day" in the State of Illinois in honor of the date its discovery was announced in 1930
  - Luckily for me, it never passes overhead in Illinois!
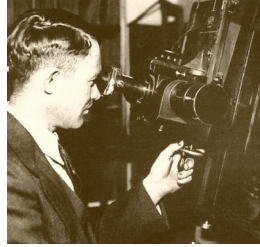
Ceres, Another Former Planet
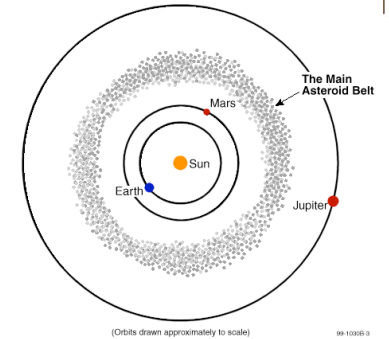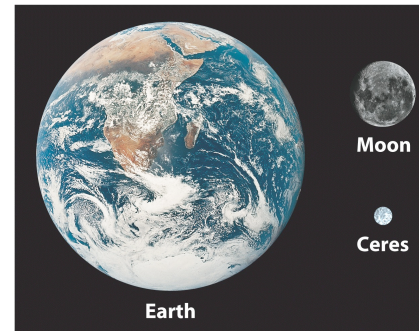
- Ceres was considered a planet for 50 years after its discovery in 1801
- Demoted after similar bodies were found
- Now, called an **asteroid**

Question

What the hell happened to Pluto?

a) It's rotational energy decreased, which pushed it out of planetary orbits.

b) We found out that Pluto is not a planet.

c) The definition of Planet was modified.

d) Other objects that may be bigger than Pluto were found.

e) It just plain ran out of luck.

What's this Universe All about Then?

- Planets are now defined
- Stars – Nuclear burning machines, usually turning hydrogen into helium
  - Colors (temperatures: cold/red to hot/blue),
  - Sizes (Jupiter-sized to 1000x the Sun)
  - Masses (80x Jupiter to 100x the Sun)
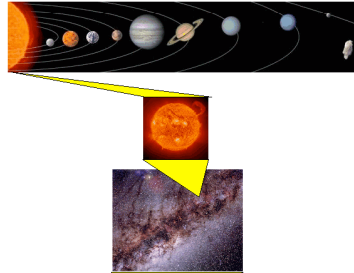 - Ages (Just born to nearly the age of the Universe)


Night sky
Dan Thurs 06/11/00

One of

We are:

- 1 planet out of ~~8~~ in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- What's next? This took until the 1920s to suss.


Those weird Spiral Nebulae?

- Dim, diffuse, "interstellar" nebulae with spiral structure were seen in the 17th century.
- Some disagreement on what they were.
  1) "A galaxy is a spiral "island universe" and the other spiral nebulae are the same and far away"
  2) "Milky Way is all there is in the Universe, and the spiral nebulae are nearby."

Galaxy   Sun
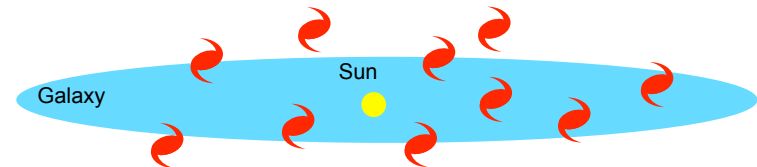
Edwin Hubble: Solved It

- In 1923, Hubble resolved M31, the Andromeda "Nebula", into stars
- If these stars were like the stars in our Galaxy, then M31 must be far away!
- Estimated the distance to M31 to be 1 million light-years (modern estimate is 2.5 million light years)
- Andromeda is an "island universe" like our own Galaxy.

Hubble at Mt. Wilson Observatory

The Andromeda "Nebula"
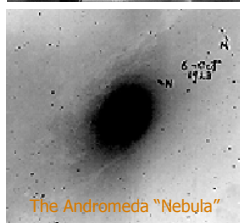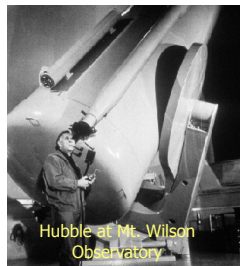
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- Stars – Nuclear burning machines, usually turning hydrogen into helium
  - Colors (temperatures: cold/red to hot/blue),
  - Sizes (Jupiter-sized to 1000x the Sun)
  - Masses (80x Jupiter to 100x the Sun)
  - Ages (Just born to nearly the age of the Universe)
- Galaxies
  - Collection of stars, gas, and dust (huge!) that are very far away.
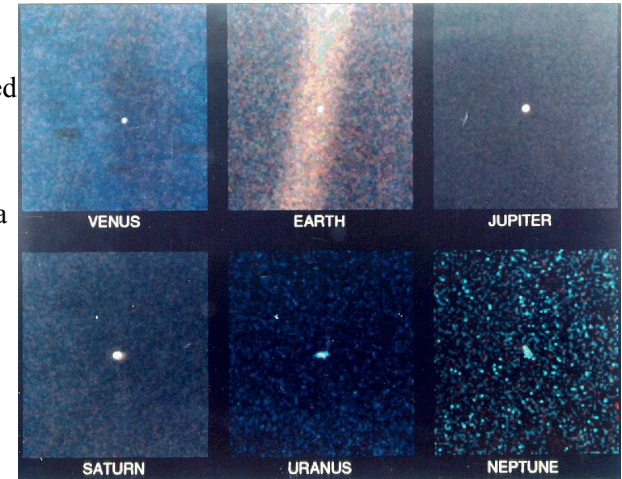
Special?

We are:

- Not, the center of the Solar System.
- Not, the center of the Galaxy.
- Not, the center of the Universe.
- Not special?
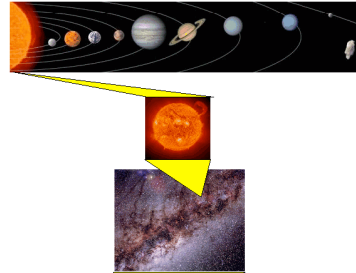
Perspective of Scale

Images from Voyager (launched in 1974) at 4 billion miles out. Moving at 100 times faster than a speeding bullet. And just recently made it into interstellar space.

VENUS   EARTH   JUPITER

SATURN   URANUS   NEPTUNE

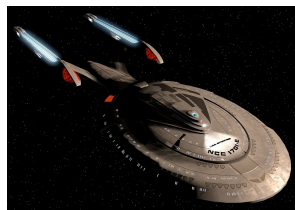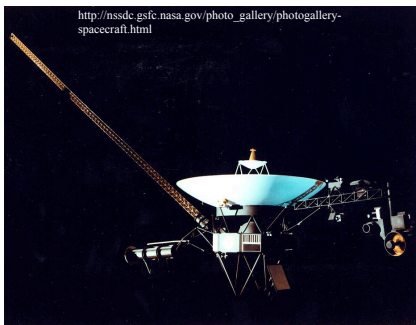http://seds.lpl.arizona.edu/nineplanets/nineplanets/overview.html

Interstellar Travel

Don't forget that the Voyager spacecraft are about the fastest vehicles made by mankind. Even so, Voyager would take over 100,000 years to reach some of the closest star systems.

http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-spacecraft.html

What's the Fastest Way?
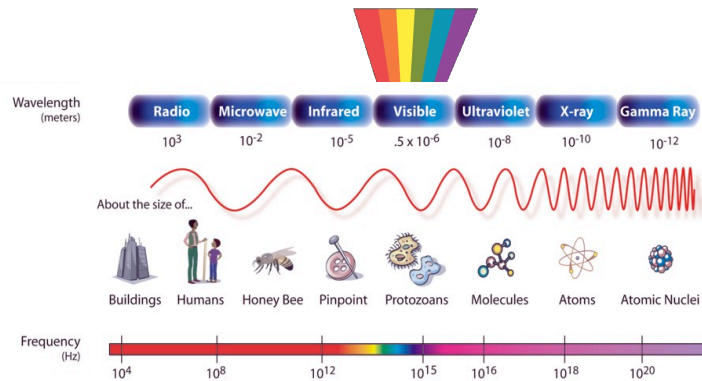
- Let's look into the constant speeder– light!
- Fastest thing out there.
- Nothing faster allowed– we'll talk more about this later.

SPEED LIMIT
299,792,458
m/s

What is Light?

- Visible light is only a tiny portion of the full electromagnetic spectrum
- Light comes in many colors that you can not see! The color x-ray or color radio or color microwave.
- Divisions between regions are really only from biology or technologies.

Distances

How far is it to Chicago?

Around 135 miles

Or 217 km

Or 712800 feet

Or 8.7 x 10^{10} microns

Or 285120 paces

Or 2 hours at car speed

Or 1 The Matrix DVD units at car speed

Or 0.7 ms at light speed

A Light Year

The **light-year**
- Distance that light travels in one year
- Speed of light: roughly 3.00×10^5 km/sec
- 3.16×10^{17} seconds in one year

so 1 light year = $(3.00 \times 10^5$ km/sec$) \times (3.16 \times 10^7$ sec$) = 9.42 \times 10^{12}$ km

- Nearest star (Proxima Centauri) is about 4.2 light years away.
- Analogous to saying: Chicago is about 2 hours away.

Question

I want to send a signal to the nearby star Alpha-Centauri (there might be ETs), which is 4.2 light years away, as quickly as possible. What wavelength of light do I use?

a) Radio waves
b) X-rays
c) Optical light
d) Infrared light
e) They are all the same speed.

Question

I want to send a signal to the nearby star Alpha-Centauri (there might be ETs), which is 4.2 light years away. How long will it take to reach Alpha-Centauri?

a) 4.2 years

b) 4.2 years times two = 8.4 year

c) Forever

d) 42 years

e) 4.2 years divided by two = 2.1 years

First Contact?

- It will take 8.4 years to send out a radio message and get a response.
- It will take 100,000 years to travel on a Voyager-like spacecraft.
- For stars in the sword of Orion, light takes 3000 years, but that is still nearby!
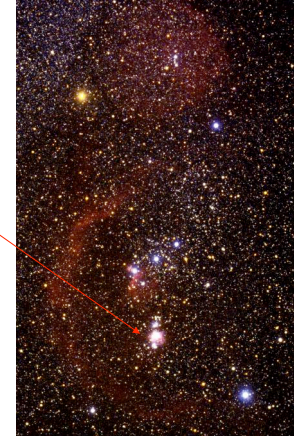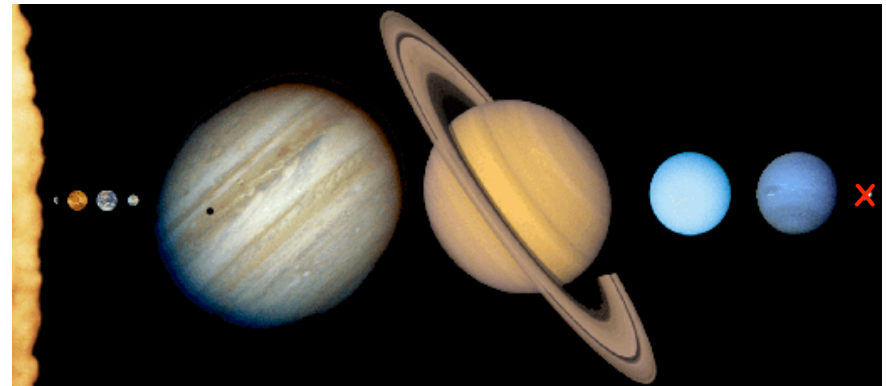

Other Distances

- 1 light year is 9.42×10^{12} km

- AU: the distance from the Sun to the Earth = 149,570,000 km = 1.58×10^{-5} light years

- pc: the distance away that a star would have a parallax of 1 arcsec, so 1 pc = 3.086×10^{13} km = 3.26 light years

Size Scales

To put astronomical scales into a reference, imagine a model of our Solar System.

Scale it:
The Most Math You'll Do in This Class

In small groups:

Assume the Sun is almost the size of my softball
    (diameter = 4 inches) to make a scaled model of the Solar System.

Calculate the scaled distance from the softball to the "Earth".   (Hint use
    ratios to figure out the answer.)

a) 4.29 feet
b) 129.5 feet
c) 35.8 feet
d) 32.2 inches
e) 49.6 feet

Sun's diameter = 1,391,900 km
distance from Earth to Sun (1 AU) = 149,570,000 km
distance from Earth to Moon = 385,000 km
1 km = 1000 meter = 3279 ft = 0.621 miles   1 mile = 5280 feet
1 light year = 9.46 x 10^{12} km = 5.87 x 10^{12} miles
Note: A million miles away from home is actually quite close!

Scale it:
The Most Math You'll Do in This Class

In small groups:

Assume the Sun is almost the size of a softball
    (diameter = 4 inches) to make my scaled model of the Solar System.

Calculate the scaled distance from the "Earth" to the "Moon".

a) 1.1 inches
b) 11.0 inches
c) 38.8 inches
d) 0.9 inches
e) 0.1 inches

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distance from Earth to Sun (1 AU) = 149,570,000 km
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